FALL 2009 PHYSICS 827 DUE FRIDAY 16^{th} OCTOBER 2009

Here are some freshman level problems. Remember that you will get zero points if your numerical answer is not sufficiently accurate or absurdly off

1.1) (a) What is the de Broglie wavelength of a baseball moving at $40m/s$? Is this a reasonable speed?
(b) What is the de Broglie wavelength of an electron whose kinetic energy is $10eV$? Write down a general answer if the kinetic energy is $a\,eV$ where a is a dimensionless number (10 in this problem) in the form $(b/\sqrt{a})\,nm$ and determine the numerical value of b. (3 points)
(c) At what wavelength λ_0 do a photon and an electron in free space have the same energy? Calculate this using a non-relativistic approximation. Is this approximation valid? How is your conclusion about the validity of the non-relativistic approximation affected by the mass of the particle you pick, i.e., instead of the electron say you pick a proton or a neutrino with a non-zero mass smaller than that of the electron? (3 points)

3.2) Feynman says that the ratio of the size of an apple to that of an atom is the same as the size of the earth to that of the apple. Check this! It is a nice way of explaining relative sizes to your relatives. (2 points)

3.3) **Photoelectric effect:** The cutoff frequency for photons for ejecting electrons from Na is found to be $4.4 \times 10^{14} s^{-1}$. What is the work function of sodium in eV ? Compare the result to the binding energy of an electron in a hydrogen atom. (2 points)

Draw a curve showing the current I vs V (both positive and negative voltages) in a photoelectric effect setup for
(i) photons with $h\nu_1 < W$ where W is the appropriate work function
(ii) photons with $h\nu_2 > W$ for a fixed intensity of incident light
(iii) same frequency as case (ii) but with twice the intensity of incident light and
(iv) with $\nu_3 = 2\nu_2$ and same intensity as (ii).
Explain your reasoning carefully. (4 points)

3.4) Shankar 1.10.4 (Page 73). You may use Mathematica or Integral tables to do the integrals to save time. (6 points)

3.5) Shankar Exercise 4.2.1 (page 129) (10 points)